4 月 April
2019, 62(4): 442 - 452

昆 虫 学 报
ACTA ENTOMOLOGICA SINICA

http://www.insect.org.cn
doi: 10.16380/j.kcxb.2019.04.006

Observation of fine structure of antennal sensilla in sexually dimorphic antennae of the blister beetle *Epicauta impressicornis* (Coleoptera: Meloidae) adults

LIU Yang-Yang[1,2], LI Guo-Yong[3], YANG Lin[1,2], CHEN Xiang-Sheng[1,2,*]

(1. Institute of Entomology, Guizhou University, Guiyang 550025, China;
2. The Provincial Special Key Laboratory for Development and Utilization of Insect Resources, Guizhou University,
Guiyang 550025, China; 3. Guizhou Provincial Key Laboratory for Rare Animal and Economic Insect of
the Mountainous Region, Guiyang University, Guiyang 550005, China)

Abstract: 【Aim】 The aim of this study is to observe the morphological characteristics of the main antennal sensilla of the blister beetle *Epicauta impressicornis* (Coleoptera, Meloidae) so as to provide a reference basis for further studying the biology and behavioral mechanisms of *E. impressicornis*, and a prerequisite for future electrophysiological studies of its antennal sensilla. 【Methods】 The morphology of the antennal sensilla of *E. impressicornis* adults was observed under scanning electron microscopy, and the quantity, distribution and the difference in antennal sensilla between the male and female were statistically and comparatively analyzed. 【Results】 The results revealed that the antennal sensilla of *E. impressicornis* adults show sexual dimorphism, and their type, abundance, and distribution have similarities and differences between both sexes. Seven types of sensilla, including sensilla chaetica type 1 (CH1), sensilla chaetica type 2 (CH2), sensilla basiconica type 1 (SB1), sensilla basiconica type 2 (SB2), Böhm sensilla (BB), sensilla auricillica (SA), and sensilla campaniformia (CA) were found on the antennae of both sexes. In addition, there are some unique sensilla including sensilla chaetica type 3 (CH3) and sensilla basiconica type 3 (SB3) on the male antennae, and sensilla basiconica type 4 (SB4), sensilla basiconica type 5 (SB5) and grooved pegs (GP) on the female antennae. 【Conclusion】 The types of antennal sensilla of *E. impressicornis* are rich and diverse. These antennal sensilla are speculated to function as pheromone receptors (CH1), chemoreceptors (CH2 and GP), olfactory receptors (CH3, SB1 - SB5, SA and CA), mechanoreceptors (BB) and thermoreceptors (CA and GP) according to their morphology and distribution, as well as based on comparative analyses with the previously reported results.

Key words: *Epicauta impressicornis*; sexual dimorphism; antennal sensilla; morphology; distribution; scanning electron microscopy

1 INTRODUCTION

The antenna is a major sensory organ of insects, bearing various sensilla for perceiving external signals. Antennal sensilla play important roles in host selection, mate finding, and oviposition site location (Schneider, 1964; Ochieng *et al.*, 2000). Furthermore, the morphological study of antennae can provide a scientific basis for the classification and identification of insects (Li *et al.*, 2013a; Hempolchom *et al.*, 2016). Recently, many studies had investigated antennal sensilla of ecologically and economically significant insect species of Lepidoptera and Hymenoptera (Zhang *et al.*, 2014; Roh *et al.*, 2016). The antennal sensilla of Coleoptera including species of Elateridae, Cerambycidae, Chrysomelidae, and Carabidae were also studied (Merivee *et al.*, 1999, 2002; Faucheux, 2011; Chen *et al.*, 2014; Fukuda *et al.*, 2016; Faucheux and Kundrata, 2017). Moreover, some researchers used scanning electron microscopy (SEM) to study the antennal morphology of some species of Meloidae (*e. g.*, Bologna and Marangoni, 1986; Pinto, 1991; Bologna and Pinto, 1998, 2002; Turco *et al.*, 2003;

基金项目: 国家自然科学基金项目(81460571); 贵州省高层次创新型人才项目(黔科合人才 20154021); 贵州省科技创新人才团队建设项目(黔科合人才团队 20144001)

作者简介: 刘洋洋, 女, 1988 年 10 月生, 贵州安顺人, 博士研究生, 研究方向为药用昆虫资源开发利用研究, E-mail: tadouliuyy@126.com

[*] 通讯作者 Corresponding author, E-mail: chenxs3218@163.com

收稿日期 Received: 2018-10-10; 接受日期 Accepted: 2018-12-21

Bologna and Giulio, 2008), but they did not observe the antennal sensilla. Previous correlative studies of the morphology of antennal sensilla of Meloidae have only investigated *Meloe campanicollis* (with four types of antennal sensilla identified) (Bland, 1986), *Hycleus cichorii* (with four types of antennal sensilla identified), *H. phaleratus* (with five types of antennal sensilla identified), *Pseudabris longiventris* (with six types of antennal sensilla identified), *P. hingstoni* (with five types of antennal sensilla identified), *Mylabris calida* (with eight types of antennal sensilla identified), *M. speciosa* (with eight types of antennal sensilla identified), *Cerocoma schreberi* (with five types of antennal sensilla identified), *Epicauta chinensis* (with six types of antennal sensilla identified), and *E. ruficeps* (with six types of antennal sensilla identified) (Li *et al*., 2009, 2013a, 2013b; Zhang and Wang, 2010), but further research is needed to characterize the morphological features of antennal sensilla of other species.

The blister beetle *Epicauta impressicornis* (Coleoptera: Meloidae) has the active ingredient cantharidin, which can be used to treat various diseases because of its anti-cancer and anti-tumor effects, and thus it has great medicinal value (National Pharmacopoeia Editorial Board, 2010). The adults of *E. impressicornis* are phytophagous, mainly feeding on legumes and the flowers and leaves of other plants. Moreover, the larvae of *E. impressicornis* are semi-parasitic predators who are feeding on grasshopper eggs or honeybee pupae in hives, which makes it show both beneficial and harmful effects (Bologna *et al*., 2008; Pinto, 2009). Scientific research into *E. impressicornis* has considered its morphology, taxonomy (Liu *et al*., 2016) and ecology (Mu and Chen, 2014, 2015). However, no previous studies have employed scanning electron microscopy (SEM) to investigate the antennae of *E. impressicornis*. Therefore, in this study, we used SEM to identify the types, numbers, and morphological differences of antennal sensilla between male and female adults of *E. impressicornis*, in order to provide a scientific basis for obtaining a better understanding of the biology and behavioral mechanisms of *E. impressicornis*, and a prerequisite for future electrophysiological studies of its antennal sensilla.

2 MATERIALS AND METHODS

2.1 Sample source

Adult males and females of *E. impressicornis* (Fig. 1: A and B) were collected from the ridges of paddy field in Luokun Village, Luodian County, Guizhou Province, China (106.58°E, 25.42°N) on 10th May, 2018. They were reared at 29℃, relative humidity 75% – 80% and photoperiod 14L∶10D in a climatic cabinet in the laboratory for more than three generations (Liu *et al*., 2018).

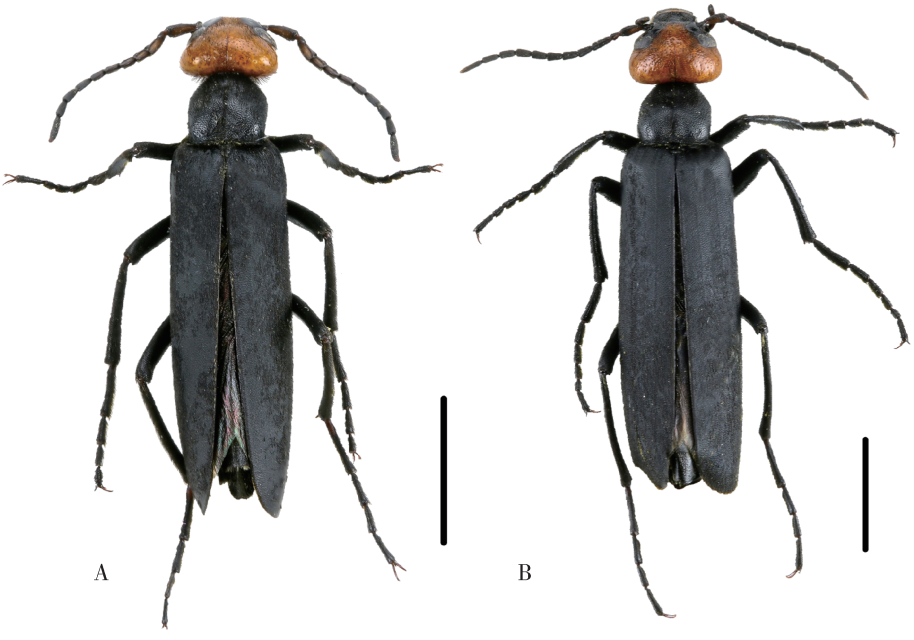

Fig. 1　Habitus of female (A) and male (B) adults of *Epicauta impressicornis* in dorsal view
Scale bars = 0.5 mm.

2.2 Sample preparation and SEM observation

Freshly emerged *E. impressicornis* adults (1 or 2 d-old) (females: N = 8; males: N = 8) obtained from the laboratory-reared population were placed in a refrigerator at 4℃ to cool for 20 min. The antennae were removed with a sharp scalpel under a stereo microscope (M125, Leica, Germany), cleaned with an ultrasonic cleaner (HS10260D, Hengao, China) for 2 min, and then washed five times with sterile distilled water. After cleaning, the samples were dehydrated in the following graded alcohol series: 30%, 50%, 70%, 80%, 90%, and anhydrous ethanol, for 20 min at each concentration. After freeze drying, the samples were attached to SEM stubs with conductive tape, and coated with gold using a sputter coater (E-1010, Hitachi, Japan). The antennae were examined by SEM (JSM-6490LV, JEOL, Japan), and the distribution and size of sensilla were recorded and measured.

2.3 Statistical data analysis

The sensilla on the dorsal and ventral surfaces of the antennae of *E. impressicornis* were identified and counted, and their length and basal diameter were measured. The terminologies defined by Schneider (1964) and Zacharuk (1985) were employed to classify and describe the sensilla. The data obtained were analyzed to determine the standard error (*SE*). The means (± *SE*) of the number and sizes of sensilla of male and female antennae were compared using a *t*-test with SPSS22.0 software (SPSS Inc., Chicago, IL, USA).

3 RESULTS

3.1 Gross antennal morphology of *E. impressicornis* adults

The antennae of *E. impressicornis* adults are filiform with eleven segments: scape, pedicel, and flagellum with nine flagellomeres (Fig. 2: A and B). The antennae of *E. impressicornis* adults show sexual dimorphism. The length of male antenna is approximately 6.78 ± 0.41 mm (Table 1 and Fig. 2: A) and the antennomeres are slightly serrated. By contrast, the female antenna is not serrated and the length of antenna is approximately 7.75 ± 0.44 mm (Table 1 and Fig. 2: B). The scape is the longest segment in both sexes and the pedicel is the shortest. The 3rd flagellomere is the widest in the male (approximately 0.56 ± 0.02 mm), and the scape is the widest in the female (approximately 0.36 ± 0.05 mm) (Table 1). The width increases significantly from the 1st to the 6th flagellomeres. In addition, the 9th flagellomere is longer than the other flagellomeres in the female.

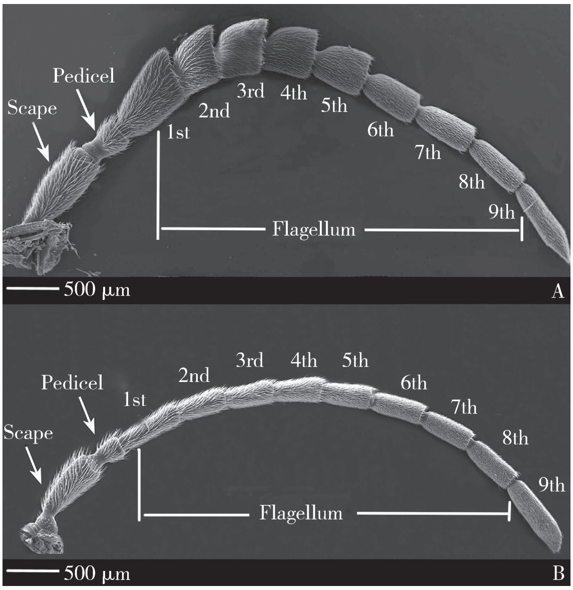

Fig. 2 General view of antennae of male (A) and female (B) adults of *Epicauta impressicornis*
1st – 9th: 1st – 9th flagellomeres, respectively.

3.2 Types and distribution of antennal sensilla of *E. impressicornis* adults

There are seven types of sensilla on the antennae of male and female adults, *i. e.*, sensilla chaetica type 1 (CH1), sensilla chaetica type 2 (CH2), sensilla basiconica type 1 (SB1), sensilla basiconica type 2 (SB2), Böhm sensilla (BB), sensilla auricillica (SA), and sensilla campaniformia (CA). In addition, there are some unique sensilla including sensilla chaetica type 3 (CH3) and sensilla basiconica type 3 (SB3) on the dorsal surface of male antenna, sensilla basiconica type 4 (SB4), sensilla basiconica type 5 (SB5) and grooved pegs (GP) on the female antenna, and SB4 on the dorsal surface of female antenna (Figs. 3 and 4). Tables 2 and 3 show the difference in the types, abundance, and distribution of various types of antennal sensilla.

3.2.1 Sensilla chaetica (CH1 – CH3): CH are the most abundant and frequent sensilla on all antennomeres in the females and males, and bent gradually from the base of the sensillum to the tip with a smooth ground surface and a pointed tip. CH can be further divided into three types, *i. e.*, sensilla chaetica type 1 (CH1), sensilla chaetica type 2 (CH2), and sensilla chaetica type 3 (CH3), according to their shapes and sizes.

CH1 are long and blunt-tipped hairs and curving from the central region, and are inserted into a shallow cuticular socket on the antennal surface

Table 1　Mean length and width (mm) of antennal segments of *Epicauta impressicornis* adults

Index	Sex	Scape	Pedicle	Flagellomeres									Total
				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	
Length	Female	1.12 ±0.02 a	0.48 ±0.03 a	0.72 ±0.04 a	0.57 ±0.04 a	0.61 ±0.04 a	0.64 ±0.05 a	0.65 ±0.05 a	0.67 ±0.05 a	0.69 ±0.04 a	0.71 ±0.04 a	0.89 ±0.06 a	7.75 ±0.44 a
	Male	0.85 ±0.04 b	0.42 ±0.03 a	0.68 ±0.05 a	0.49 ±0.05 a	0.50 ±0.05 b	0.53 ±0.04 b	0.58 ±0.04 a	0.62 ±0.04 a	0.65 ±0.03 a	0.67 ±0.04 a	0.82 ±0.04 a	6.78 ±0.41 b
Width	Female	0.36 ±0.05 b	0.22 ±0.04 a	0.19 ±0.02 b	0.27 ±0.02 b	0.29 ±0.01 b	0.31 ±0.02 b	0.29 ±0.03 a	0.26 ±0.02 a	0.25 ±0.02 a	0.22 ±0.02 a	0.24 ±0.02 a	–
	Male	0.43 ±0.02 a	0.24 ±0.03 a	0.43 ±0.04 a	0.51 ±0.03 a	0.56 ±0.02 a	0.52 ±0.03 a	0.42 ±0.03 b	0.32 ±0.03 b	0.28 ±0.02 a	0.23 ±0.02 a	0.28 ±0.02 a	–

–: Absence. Data (N = 8) in the table represent the mean ± *SE*. Means of the same index in a column followed by different letters indicate significant difference between males and females (*t*-test, $P < 0.05$).

Table 2　Abundance and distribution of antennal sensilla of various types in *Epicauta impressicornis* adults

Sensillum type	Sex	Scape	Pedicle	Flagellomere									Total
				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	
CH1	Female	–	–	3 ±0.33 b	4 ±0.46 b	7 ±0.35 b	9 ±0.19 b	13 ±0.18 b	16 ±0.50 b	20 ±0.55 b	30 ±0.68 b	54 ±1.71 b	152 ±2.16 b
	Male	–	–	4 ±0.26 a	5 ±0.34 a	8 ±0.32 a	12 ±0.32 a	14 ±0.30 a	20 ±0.71 a	30 ±0.60 a	36 ±0.85 a	59 ±0.88 a	185 ±1.30 a
CH2	Female	228 ±2.78 b	129 ±2.17 b	162 ±2.10 b	249 ±2.63 b	263 ±3.61 b	392 ±4.13 b	409 ±2.25 b	490 ±2.76 a	525 ±2.96 b	562 ±4.34 b	611 ±1.81 b	4 017 ±16.56 b
	Male	276 ±3.84 a	161 ±2.45 a	255 ±2.53 a	294 ±2.84 a	375 ±6.31 a	416 ±2.70 a	434 ±2.60 a	451 ±1.31 b	463 ±3.27 a	521 ±3.14 a	588 ±4.94 a	4 230 ±11.52 a
CH3	Female	–	–	–	–	–	–	–	–	–	–	–	–
	Male	–	–	–	–	57 ±0.11	85 ±0.65	93 ±0.91	137 ±1.03	151 ±1.21	173 ±2.31	192 ±3.27	891 ±2.36
SB1	Female	–	–	78 ±1.28 a	48 ±0.75 a	64 ±0.77 a	75 ±0.92 a	85 ±0.92 a	117 ±2.79 a	127 ±1.83 a	80 ±1.78 a	125 ±2.20 a	796 ±5.5 a
	Male	–	–	27 ±1.31 b	31 ±0.46 b	60 ±1.05 a	67 ±0.75 b	63 ±0.70 b	56 ±0.98 b	72 ±1.88 b	39 ±1.02 b	63 ±0.95 b	475 ±4.87 b
SB2	Female	–	–	–	–	–	–	18 ±0.45 b	94 ±2.11 a	223 ±3.80 a	341 ±5.44 a	428 ±5.43 a	1 102 ±13.38 a
	Male	–	–	–	–	–	–	43 ±0.96 a	55 ±2.27 b	40 ±1.47 b	33 ±1.16 b	16 ±0.65 b	185 ±3.38 b
SB3	Female	–	–	–	–	–	–	–	–	–	–	–	–
	Male	–	–	–	–	–	–	–	–	19 ±0.62	23 ±0.77	31 ±0.65	73 ±3.46
SB4	Female	–	–	–	–	32 ±3.32	48 ±3.56	55 ±4.18	67 ±2.12	74 ±2.62	78 ±2.32	86 ±1.32	571 ±2.43
	Male	–	–	–	–								
SB5	Female	–	–	–	–	–	–	–	82 ±1.54	151 ±2.59	218 ±2.17	341 ±4.43	709 ±2.25
	Male	–	–	–	–	–	–	–	–	–	–	–	–
BB	Female	32 ±0.90 b	17 ±1.15 b	–	–	–	–	–	–	–	–	–	49 ±1.99 b
	Male	51 ±0.73 a	46 ±1.24 a	–	–	–	–	–	–	–	–	–	98 ±1.91 a
SA	Female	–	–	–	–	–	–	–	16 ±0.50 b	20 ±0.55 b	30 ±0.68 b	54 ±1.71 b	123 ±2.16 b
	Male	–	–	–	–	–	–	–	20 ±0.71 a	30 ±0.60 a	36 ±0.85 a	59 ±0.88 a	145 ±1.30 a
CA	Female	–	–	–	23 ±0.72	37 ±0.65	16 ±0.41 b	28 ±0.70 b	34 ±1.26 b	84 ±2.20 b	121 ±1.70 b	148 ±4.90 b	419 ±5.32 b
	Male	–	–	–	–	–	32 ±0.35 a	44 ±0.32 a	62 ±2.01 a	113 ±1.24 a	148 ±1.65 a	216 ±1.64 a	615 ±2.58 a
GP	Female	–	–	–	–	56 ±3.21	61 ±2.56	72 ±3.26	96 ±3.82	115 ±2.13	126 ±1.28	211 ±4.05	754 ±5.31
	Male	–	–	–	–	–	–	–	–	–	–	–	–

CH1: Sensilla chaetica type 1; CH2: Sensilla chaetica type 2; CH3: Sensilla chaetica type 3; SB1: Sensilla basiconica type 1; SB2: Sensilla basiconica type 2; SB3: Sensilla basiconica type 3; SB4: Sensilla basiconica type 4; SB5: Sensilla basiconica type 5; BB: Böhm sensilla; SA: Sensilla auricillica; CA: Sensilla campaniformia; GP: Grooved pegs; –: Absence. The same for Table 3. Means (N = 8) of the same sensillum in a column followed by different letters indicate significant difference between males and females (*t*-test, $P < 0.05$).

Table 3 Size and shape of antennal sensilla of various types identified in *Epicauta impressicornis* adults

Sensillum type	Length (μm)		Basal diameter (μm)		Tip	Wall	Shape	Socket
	Female	Male	Female	Male				
CH1	105.61 ±0.33 a	94.55 ±0.42 b	6.50 ±0.04 a	3.54 ±0.01 b	Blunt	Grooved	Curved, hair-like	Tight
CH2	76.08 ±0.26 a	70.38 ±0.41 b	3.35 ±0.11 a	3.41 ±0.10 a	Sharp	Grooved	Curved, hair-like	Tight
CH3	–	18.22 ±0.28	–	1.94 ±0.05	Sharp	Grooved	Curved, hair-like	Tight
SB1	5.71 ±0.11 a	7.33 ±0.04 b	1.97 ±0.03 a	2.47 ±0.05 b	Blunt	Smooth	Straight, cylindrical	Tight
SB2	6.00 ±0.06 a	7.53 ±0.07 b	2.59 ±0.03 a	2.40 ±0.06 b	Blunt	Smooth	Curved, peg-like	Tight
SB3	–	15.43 ±0.21	–	2.14 ±0.03	Blunt	Grooved	Curved, hair-like	Wide
SB4	2.11 ±0.05	–	1.02 ±0.03	–	Blunt	Smooth	Straight	Wide
SB5	6.66 ±0.09	–	2.41 ±0.22	–	Blunt	Smooth	Straight, protuberant bolt	Tight
BB	21.21 ±0.66 a	23.14 ±0.92 a	3.21 ±0.11 a	3.27 ±0.10 a	Sharp	Smooth	Straight, thorn-like	Wide
SA	5.39 ±0.09 a	5.75 ±0.06 a	1.48 ±0.05 a	1.54 ±0.07 a	Blunt	Smooth	Straight, rabbit-ear	Wide
CA	–	–	2.98 ±0.13 a	2.72 ±0.10 a	Blunt	Smooth	Hemispherical or cap-like	Wide
GP	4.37 ±0.08	–	1.23 ±0.06	–	Blunt	Grooved	Straight	Wide

Means (N = 8) of the same index in a row followed by different letters indicate significant difference between males and females (*t*-test, $P < 0.05$).

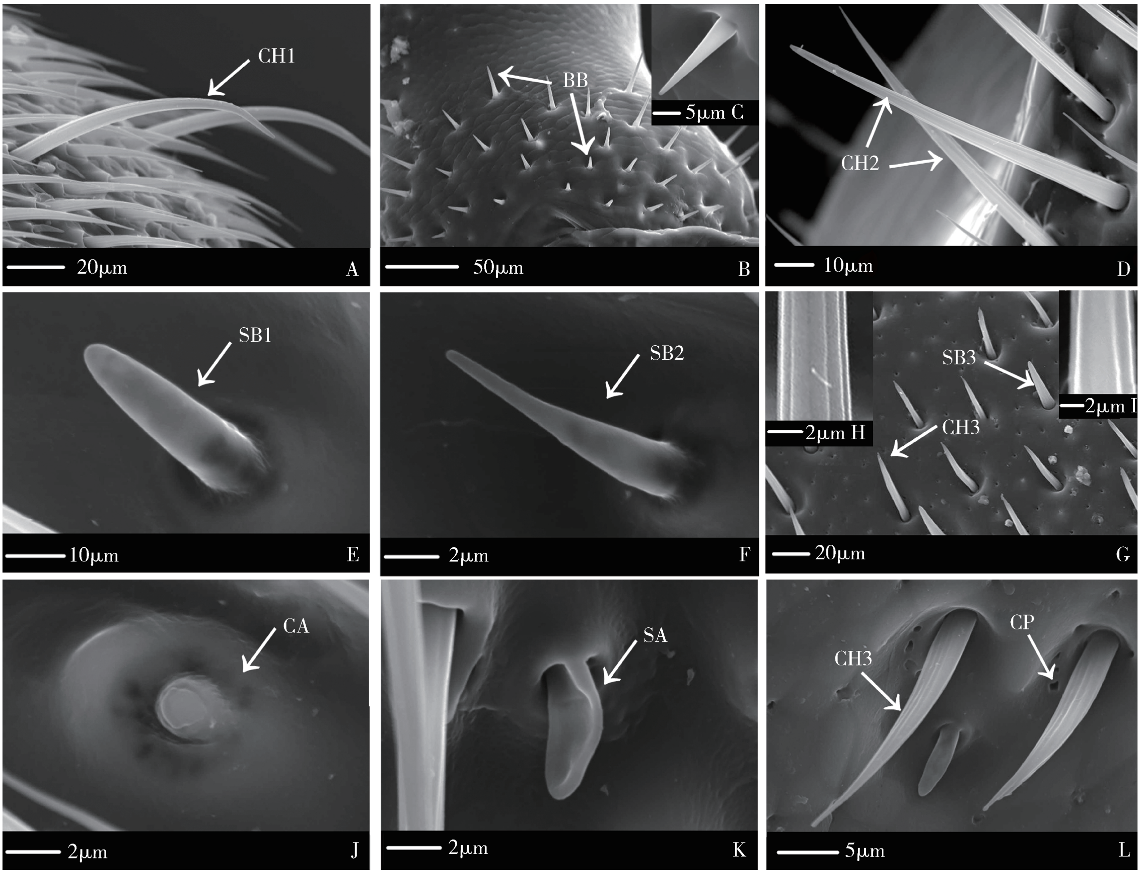

Fig. 3 Antennal sensilla of male adults of *Epicauta impressicornis*

A: Middle of the 9th flagellomere, ventral side; B: Base of pedicel, ventral side; C: BB of the thorn-like shape with smooth walls at higher magnification; D: Inside the 1st flagellomere, ventral side; E: Inside of the 3rd flagellomere, ventral side; F: Inside of the 5th flagellomere, ventral side; G: Inside of the 3rd flagellomere, dorsal side; H: Longitudinal grooves on the wall of CH3; I: Longitudinal grooves on the wall of SB3; J: Inside of the 4th flagellomere, ventral side; K: Middle of the 7th flagellomere, ventral side; L: Inside of the 6th flagellomere, dorsal side. CH1: Sensilla chaetica type 1; CH2: Sensilla chaetica type 2; CH3: Sensilla chaetica type 3; BB: Böhm sensilla; SB1: Sensilla basiconica type 1; SB2: Sensilla basiconica type 2; SB3: Sensilla basiconica type 3; CA: Sensilla campaniformia; SA: Sensilla auricillica; CP: Cuticular pores.

(Table 3; Fig. 3: A; and Fig. 4: A, C). CH1 are present on all flagellomeres in both sexes. There are less CH1 on the female antenna than on the male antenna (Table 2). The sizes of CH1 differ significantly between females and males (Table 3). They are more frequent on the distal segments (Table 2).

CH2 bent gradually from the base of the

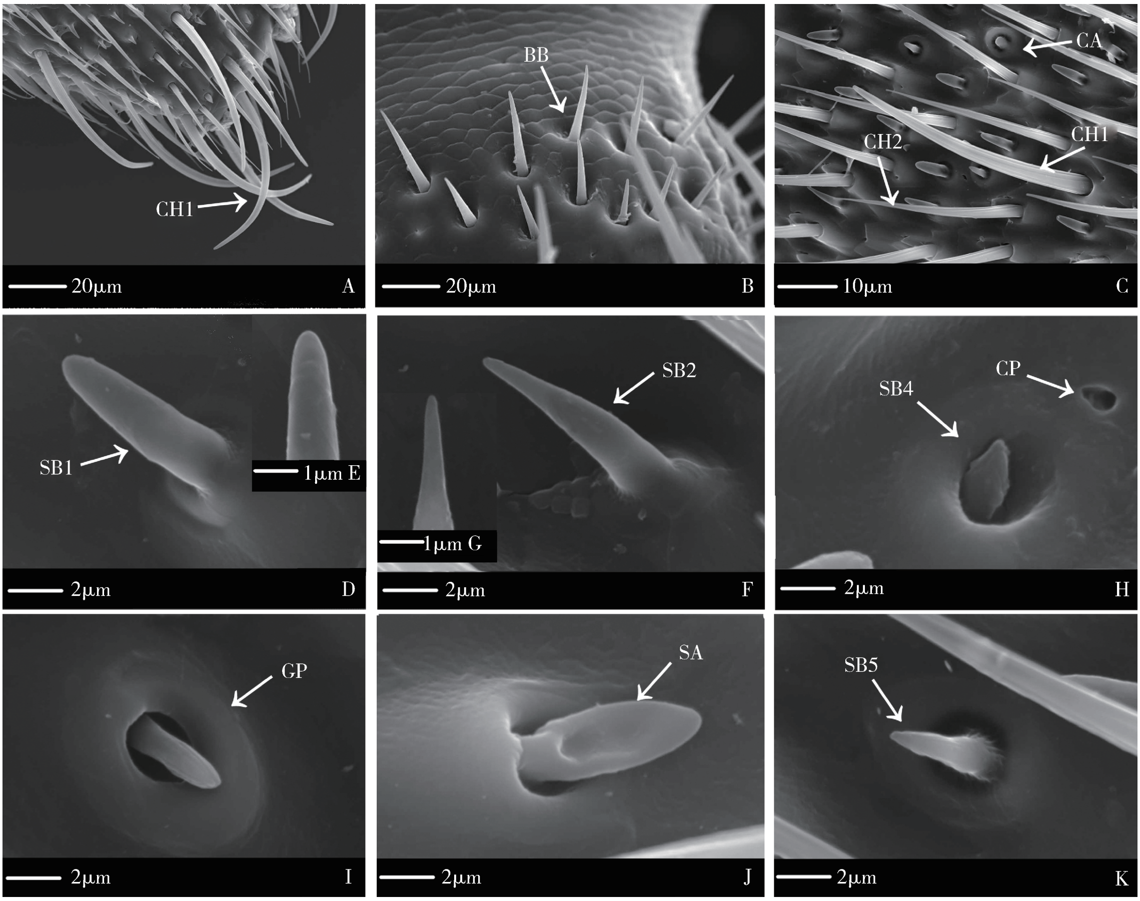

Fig. 4　Antennal sensilla of female adults of *Epicauta impressicornis*

A: Distal part of the 9th flagellomere, ventral side; B: Base of pedicel, ventral side; C: Inside of the 2nd flagellomere, ventral side; D: Inside of the 3rd flagellomere, ventral side; E: The smooth cuticle of SB1 at higher magnification; F: Inside of the 5th flagellomere, ventral side; G: The smooth cuticle of SB2 at higher magnification; H: Inside of the 8th flagellomere, dorsal side; I: Inside of the 7th flagellomere, ventral side; J: Middle of the 6th flagellomere, ventral side; K: Inside of the 6th flagellomere, ventral side. CH1: Sensilla chaetica type 1; CH2: Sensilla chaetica type 2; BB: Böhm sensilla; CA: Sensilla campaniformia; SB1: Sensilla basiconica type 1; SB2: Sensilla basiconica type 2; SB4: Sensilla basiconica type 4; SB5: Sensilla basiconica type 5; GP: Grooved pegs; SA: Sensilla auricillica; CP: Cuticular pores.

sensillum to the tip, with sharp-tipped hairs and strong longitudinal grooves. The antennal shaft is slightly curved and inserted tightly into a cuticular base socket (Table 3; Fig. 3: D; and Fig. 4: C). CH2 are distributed on each segment in both sexes and they are more numerous than CH1. In addition, they become more frequent on the tip of the flagellum (Table 2). The length of CH2 differs significantly between the two sexes (Table 3), but the basal diameter does not differ between the sexes.

CH3 are only present on the dorsal surface between the 3rd and the 9th flagellomeres of male (Table 2), and become more frequent toward distal flagellomeres. They are about 18.22 ± 0.28 μm in length and 1.94 ± 0.05 μm in basal diamerer (Table 3 and Fig. 3: G, H, L), fairly similar to the SB3. However, CH3 and SB3 could be distinguished by the sharp tip (Fig. 3: G, L).

3.2.2　Sensilla basiconica (SB1 – SB5): Five types of SB including sensilla basiconica type 1 (SB1), sensilla basiconica type 2 (SB2), sensilla basiconica type 3 (SB3), sensilla basiconica type 4 (SB4) and sensilla basiconica type 5 (SB5) were identified according to their morphology and sizes. The abundance of SB depends on the flagellomere. SB are straight and shorter than CH.

SB1 have blunt tips and they are located on the 1st – 9th flagellomeres. They are more abundant and frequent toward the distal segments, with significantly higher numbers on the female antennae than on the male antennae (Table 2). The shaft is smooth without longitudinal grooves (Table 3; Fig. 3: E; and Fig. 4: D, E). SB1 on the female antennae are significantly shorter and thinner than those on the male antennae (Table 3).

SB2 are slightly curved peg-like with a blunted tip. They are present on the 5th – 9th flagellomeres of both sexes. The shaft is smooth without longitudinal grooves (Table 2; Fig. 3: F; and Fig. 4: F, G). SB2 differ significantly in length and basal diameter between the sexes (Table 3). SB2 are more abundant on the female antennae than on the male antennae (Table 2).

SB3, occur as the same as CH3 (Table 2), are relatively blunt and shorter than CH3. They are 15.43 ± 0.21 μm in length and 2.14 ± 0.03 μm in basal diameter (Table 3 and Fig. 3: G, I). They become more frequent only on the dorsal surface of male with longitudinal grooves.

SB4 are fairly tiny cones of 2.11 ± 0.05 μm in length and 1.02 ± 0.03 μm in width, with a straight blunt tip, and they are set in a grooved cuticular socket (Table 3 and Fig. 4: H). They are present in a small number only on the 7th – 9th flagellomeres on the dorsal surface of female (Table 2).

SB5 are protuberant and bolt-shaped, and are located on the cuticle with a tight socket (Fig. 4: K). They are only distributed sporadically on the antennal flagellomeres in females (Table 2), but most are distributed on the 9th flagellomere. They are 6.66 ± 0.09 μm in length and their basal diameter is 2.41 ± 0.22 μm (Table 3).

3.2.3 Böhm sensilla (BB): BB have a thorn-like shape with smooth walls and sharp tips. They are straight and present at the base of the scape, near the joints between the scape and head, as well as in the base of pedicel, near the joint with the scape. In both sexes BB are inserted into a wide socket (Table 3; Fig. 3: B, C; and Fig. 4: B). The sizes of BB do not differ significantly between the females and males (Table 3), but their amount is significantly different between the sexes (Table 2).

3.2.4 Sensilla auricillica (SA): SA are of ‘rabbit-ear’ shape or elliptical shape with slightly bent towards the surface. Their base is stout and inserted into a wide socket on the 6th – 9th flagellomeres of both sexes. They are more frequent toward the distal segments (Table 2; Fig. 3: K; and Fig. 4: J). The total abundance of SA shows significant difference between sexes, with higher number in males than in females (Table 2), but the size is not significantly different between the sexes (Table 3).

3.2.5 Sensilla campaniformia (CA): CA are cap-like, hemispherical structures, which are surrounded by a circular smooth edge with thick walls (Table 3; Fig. 3: J; and Fig. 4: C). There are few CA on the antennal surfaces from the 2nd to the 9th flagellomeres of female and from the 4th to the 9th flagellomeres of male, and most are distributed on the 9th flagellomere of both sexes. There is significant difference in quantity on the antennae between male and female (Table 2). The basal diameter is 2.82 ± 0.10 μm in female and 2.72 ± 0.10 μm in male, respectively (Table 3).

3.2.6 Grooved pegs (GP): GP are characterized by grooved surface and straight pegs with blunt tip. They are inserted into wide sockets (Fig. 4: I), and are 4.37 ± 0.08 μm in length and the basal diameter is 1.23 ± 0.06 μm (Table 3). Most of them are only located on the 3rd – 9th flagellomeres in female. They could also be frequently found on the front side of the terminal flagellomere (Table 2).

4 DISCUSSION

The results demonstrated that the types, abundance, and distribution of antennal sensilla of *E. impressicornis* adults show sexual dimorphism. Sensilla chaetica (CH3) and sensilla basiconica (SB3) are only present on the dorsal surface of male antenna, sensilla basiconica (SB4 – SB5) and grooved pegs (GP) are only present on the female antenna, and SB4 are only present on the dorsal surface of female antenna. It was suggested that they might not only be closely related to the difference in the shape of antenna (serrata in male and filiform in female) (Schneider, 1964), but also be associated with sex-specific differences in behavior, such as courtship and host recognition (Zacharuk, 1985). The functions of sensilla were related to the ecological niche of species and its life traits apart from the sexual dimorphism (Zauli *et al*., 2016; Tian *et al*., 2018).

Sensilla chaetica (CH) can be divided into three types (CH1 – CH3), CH1 and CH2 are significantly more frequent and longer in the male than in the female (Tables 2 and 3), indicating a higher host plant or mate location recognition sensitivity in the females than in the males. Many previous studies have shown that CH respond to various salts, pH, plant sugars and amino acids, plant toxic compounds (alkaloids and glucosides), and bristle bending (Milius *et al*., 2006, 2011; Merivee *et al*., 2008, 2012; Tooming *et al*., 2012), respectively. The shape of CH1 in *E. impressicornis* is similar to that of TSIII in *Bembidion properans* (Merivee *et al*., 2002) and that of sensilla trichoid I (TSI) in *Elater ferrugineus* (Zauli *et al*., 2016), which are considered to detect aggregation pheromones. CH2 in *E. impressicornis* are also similar to those in other Coleoptera, such as Scolytidae (Faucheux, 1994), Cerambycidae (Lopes *et al*., 2002), and Curculionidae (Saïd *et al*., 2003), and CH2 maybe play roles in chemoreception. Moreover, we found that the CH3 in this study are only located on the dorsal region of the 3rd – 9th flagellomeres of male antennae (Table 2), and the shape of CH3 resembles that of sensilla trichoid type 2 (tr. 2) in *C. schreberi* (Li *et al.*, 2013b), indicating the importance of CH3 in the functioning of the adult male antennae. However, it is thus possible that CH3 might have a great relationship with the same position of SB3. Hence, CH3 on the male antennae will be discussed together with SB3 in the latter section.

There are five main types of sensilla basiconica (SB1 – SB5) in *E. impressicornis*, including SB1 and SB2 in both sexes, SB3 in male, SB4 and SB5 in female, respectively (Tables 2 and 3). We also observed that SB1 and SB2 are more significantly abundant in female than in male. In addition, SB1 and SB2 are significantly longer in male than in female, and their basal diameters also differ significantly in both sexes (Tables 2 and 3). The resemblance between SB1 in *E. impressicornis* and TSI in *Acanthoscelides obtectus* (Say, 1831) is remarkable. SB2 in *E. impressicornis* are similar to the SB1 of *Xylotrechus grayii* (Chen *et al.*, 2014) and *Anoplophora glabripennis* (Xu *et al.*, 2015). SB3 were found as the same as CH3 in site and have similar shape to sensilla basiconica type 5 (s. b. 5) in *B. properans* (Merivee *et al.*, 2002). SB4 are the shortest and the least in SB types (Tables 2 and 3), and similar sensilla (s. b. 4) were found in *B. properans* (Merivee *et al.*, 2002). SB5 were found specifically in *E. impressicornis* females with an enlarged base, and they have similar shape to the sensilla styloconica (StS) that the sensory cone is articulated on the hight stylus (Faucheux, 1999). It is presumed on the basis of SB ultrastructure that SB types (SB1 – SB5) are most likely olfactory receptors which are known to receive various chemical stimuli from some insects (Missbach *et al.*, 2014; Urbanek *et al.*, 2016). Different SB subtypes might detect different odor molecules. However, it is necessary for further investigation by a detailed electrophysiological study.

Böhm sensilla (BB) are present on the base of the scape and pedicel at the joints between the scape and the head, as well as between the scape and the pedicel in female and male adults of *E. impressicornis*. BB are more abundant in males than in females. There is no significant difference in the length of BB between sexes (Tables 2 and 3). Li *et al.* (2009, 2013a, 2013b) reported that BB were present in *E. chinensis*, *H. cichorii*, and *C. schreberi*, and their positions were consistent with those in *E. impressicornis*, suggesting a conserved nature of their distribution. BB were inferred to be mechanoreceptors that respond to gravity under mechanical stimulation, thereby controlling the up and down movements of the antenna and their speed (Ochieng *et al.*, 2000; Faucheux and Kundrata, 2017).

The morphology of sensilla auricillica (SA) of *E. impressicornis*, are ‘rabbit-ear’ shape or elliptical shape with a depression in the middle, which are located in half opening sockets (Fig. 3: K; and Fig. 4: J). However, similar sensilla auricillica have been rarely observed in other coleopteran insects, such as *Monochamus alternatus* (Sun *et al.*, 2010) and ground beetle *Platynus dorsalis* (Coleoptera, Carabidae) (Merivee *et al.*, 2001). Sensilla auricillica were found to be a common type of sensilla on the antenna of most insects (Diptera and Lepidoptera) (Ross and Anderson, 1987; Faucheux, 2012; Roh *et al.*, 2016). SA were considered to be olfactory receptors for plant volatiles, respond to sex pheromone components and contain neurons that were thermo-sensitive or responsive to carbon dioxide (CO_2) in moths, including *Delia radicum* (Ross and Anderson, 1987), *Scoliopteryx libatrix* (Anderson *et al.*, 2000) and *Cydia pomonella* (Ansebo *et al.*, 2005).

Sensilla campaniformia (CA) was described as thick-walled, semispherical or semiellipsoidical structures of the cuticle by Schneider (1964). They are present on both sexes of *E. impressicornis*, and are proprioceptors which respond to strains in the cuticle (McIver, 1975). The type of CA in *E. impressicornis* is similar to those in other species. For example in *Melanotus villosus* (Merivee *et al.*, 1999), *B. properans* (Merivee *et al.*, 2002), *Atta vollenweideri* (Ruchty *et al.*, 2009) and *E. chinensis* (Li *et al.*, 2009). CA were known to be innervated by cold-sensitive neurons that respond to cold air, although this type of sensilla has also been described as odorant receptors (Ruchty *et al.*, 2009; Zhang *et al.*, 2014). Thus, CA were considered to be temperature and olfactory receptors (Merivee *et al.*, 1999, 2002). Their functions on beetles’ antennae still need further research.

Grooved pegs (GP), are peculiarly distributed on the 3rd – 9th flagellomeres in female of *E. impressicornis* (Table 2), and are homologous to GP of *E. ferrugineus* (Zauli *et al.*, 2016) and *X. grayii* (Chen *et al.*, 2014) in terms of the morphological characteristics. In addition, the probable function of GP was chemo- or thermo-reception (Zacharuk, 1985), the function of GP of *E. impressicornis* is supposed to be the same and still needs to be clarified.

In addition to the above types of antennal sensilla, there are many cuticular pores (CP), which are the openings of epidermal glandsn but not sensilla. Large numbers of CP are present on the flagellum, where they vary in terms of their size and location, but they were found on all the antennal surfaces. The number of CP is higher in males than in females, and in male, there are more CP on the dorsal view than on the ventral view. (Fig. 3: L; and Fig. 4: H). They are present on the antennae in both sexes of *E. impressicornis* with different size and quantity, suggesting differences in the function of respective cuticular glands. It had been reported that CP functions in touch and chemoreception, as well as in the detection of humidity and temperature in *Callosobruchus chinensis* (Medvedev and Pavlov, 1988; Merivee *et al*., 2002). However, in most antennae of insects, the cuticular pores might possess a lubricant role in the integument (Faucheux and Kundrata, 2017).

In conclusion, we determined the distribution, shape, type, and quantity of antennal sensilla in both sexes of adult *E. impressicornis*. The male antenna is serrated, whereas the female antenna is filiform. The antennae are shorter in males than in females, but the width of the male antenna is significantly larger, presumably to allow the insertion of different sensilla involved with the searching for females and mating. The sensilla of adult *E. impressicornis* comprise CH (three types), SB (five types), BB, SA, CA, and GP. CH3 and SB3 are only present in males and SB4 – SB5 and GP only in females. The analyses and speculation of the function of antennal sensilla were based on comparative analyses with the previously reported summary and results. Therefore, in future studies, the functions of the antennal sensilla identified need to be elucidated in behavioral and electrophysiological studies.

ACKNOWLEDGEMENTS We would like to thank LEI Ping (Senior Experimenter) from Guizhou Normal University for assistance during the experiments. This research was supported by the National Natural Science Foundation of China (No. 81460571), the Program of Science and Technology Innovation Talents Team, Guizhou Province, China (No. 20144001) and the Program of Excellent Innovation Talents, Guizhou Province, China (No. 20154021).

References

Anderson P, Hallberg E, Subchev M, 2000. Morphology of antennal sensilla auricillica and their detection of plant volatiles in the herald moth, *Scoliopteryx libatrix* L. (Lepidoptera: Noctuidae). *Arthropod Struct. Dev*., 29(1): 33 – 41.

Ansebo L, Ignell R, Löfqvist J, Hansson BS, 2005. Responses to sex pheromone and plant odours by olfactory receptor neurons housed in sensilla auricillica of the codling moth, *Cydia pomonella* (Lepidoptera: Tortricidae). *J. Insect Physiol*., 51(10): 1066 – 1074.

Bland RG, 1986. Antennal and mouthpart sensilla of the blister beetle, *Meloe campanicollis* (Coleoptera: Meloidae). *Great Lakes Entomol*., 19(4): 209 – 215.

Bologna MA, Giulio AD, 2008. Revision of the genus *Trichomeloe* Reitter, with the description of new species and first instar larvae (Coleoptera: Meloidae). *Contrib. Zool*., 77(4): 227 – 248.

Bologna MA, Marangoni C, 1986. Sexual behaviour in some Palaearctic species of *Meloe* (Coleoptera: Meloidae). *Bull. Soc. Ent. Ital*., 118: 65 – 82.

Bologna MA, Oliverio M, Pitzalis M, Mariottini P, 2008. Phylogeny and evolutionary history of the blister beetles (Coleoptera, Meloidae). *Mol. Phylogenet. Evol*., 48(2): 679 – 693.

Bologna MA, Pinto JD, 1998. A review of the Afrotropical species of *Meloe* Linnaeus, 1758 (Coleoptera, Meloidae) with descriptions of first instar larvae, a key to species and an annotated catalogue. *Monitore Zool. Ital. Suppl*., 11(1): 9 – 5.

Bologna MA, Pinto JD, 2002. The Old World genera of Meloidae (Coleoptera): a key and synopsis. *J. Nat. Hist*., 36: 2013 – 2102.

Chen JM, Qiao HL, Xu CQ, Liu S, Lian ZM, Guo K, 2014. Observation of antennal sensilla in *Xylotrechus grayii* (Coleoptera: Cerambycidae) with scanning electron microscopy. *Microsc. Res. Tech*., 77(4): 264 – 273.

Faucheux MJ, 1994. Distribution and abundance of antennal sensilla from two populations of the pine engraver beetle, *Ips pini* (Say) (Coleoptera: Scolytidae). *Ann. Sci. Nat. Zool*., 15: 15 – 31.

Faucheux MJ, 1999. Biodiversity and Unity of Sensory Organs in Lepidopteran Insects. Société des Sciences naturelles de l'Ouest de la France, Nantes. 296 pp.

Faucheux MJ, 2011. Antennal sensilla of the yellow beetle *Phoracantha recurva* Newman, 1840 distribution and comparison with *Phoracantha semipunctata* (Fabricius, 1775) (Coleoptera: Cerambycidae). *Bull. Inst. Sci*., 33(1): 19 – 29.

Faucheux MJ, 2012. Wall-pore sensilla auricillica on the labial palps of *Limnephilus marmoratus* Curtis 1834 (Trichoptera: Limnephilidae). *Ann. Soc. Entomol*., 48(1 – 2): 229 – 231.

Faucheux MJ, Kundrata R, 2017. Comparative antennal morphology of male Drilini with special reference to the sensilla (Coleoptera: Elateridae: Agrypninae). *Zool. Anz*., 266: 105 – 119.

Fukuda K, Yanagawa A, Tuda M, Sakurai G, Kamitani S, Furuya N, 2016. Sexual difference in antennal sensilla abundance, density and size in *Callosobruchus rhodesianus* (Coleoptera: Chrysomelidae: Bruchinae). *Appl. Entomol. Zool*., 51(4): 641 – 651.

Hempolchom C, Yasanga T, Wijit A, Taai K, Dedkhad W, Srisuka W, Thongsahuan S, Otsuka Y, Takaoka H, Saeung A, 2016. Scanning electron microscopy of antennal sensilla of the eight *Anopheles* species of the Hyrcanus Group (Diptera: Culicidae) in Thailand. *Parasitol. Res*., 116(1): 143 – 153.

Li XM, Ren GD, Wang XP, 2009. Antennal morphology and distribution of sensilia types of *Epicauta chinensis* Laporte. *J. Hebei Univ*., 29(4): 421 – 426. [李秀敏, 任国栋, 王新谱, 2009. 中华豆芫菁的触角感器与类型分布. 河北大学学报, 29(4): 421 – 426]

Li XM, Ren GD, Wang XP, 2013a. Analysis of the taxonomic and phylogenetic relationships of Mylabrini species (Coleoptera, Meloidae) based on antennal sensilla morphology. *Chin. J. Appl. Entomol*., 50(1): 242 – 252. [李秀敏, 任国栋, 王新谱, 2013a. 基于触角感器的部分芫菁属、种类地位和关系分析(鞘翅目: 芫菁科). 应用昆虫学报, 50(1): 242 – 252]

Li XM, Ren GD, Wang XP, 2013b. Fine structures of the antennal sensilla from sexually dimorphic antenna of *Cerocoma schreberi* Fabricius, 1781 (Coleoptera, Meloidae). *J. Hebei Univ*., 33(4): 408 – 412. [李秀敏, 任国栋, 王新谱, 2013b. 蓝绿齿角芫菁异型触角的扫描电镜观察(鞘翅目: 芫菁科). 河北大学学报, 33(4): 408 – 412]

Liu YY, Li GY, Yang L, Chi H, Chen XS, 2018. Demography and mass rearing of the medicinal blister beetle *Epicauta impressicornis* (Pic) (Coleoptera: Meloidae) at different temperatures. *J. Econ. Entomol*., 111(5): 2364 – 2374.

Liu YY, Pan Z, Chen XS, 2016. Comparative morphological study on five medicinal *Epicauta* species from Guizhou Province. Sichuan *J. Zool*., 35(1): 84 – 92. [刘洋洋, 潘昭, 陈祥盛, 2016. 贵州5种药用豆芫菁形态比较研究. 四川动物, 35(1): 84 – 92]

Lopes O, Barata EN, Mustaparta H, Araújo J, 2002. Fine structure of antennal sensilla basiconica and their detection of plant volatiles in the eucalyptus woodborer, *Phoracantha semipunctata* Fabricius (Coleoptera: Cerambycidae). *Arthropod Struct. Dev*., 31(4): 1 – 13.

McIver SB, 1975. Structure of cuticular mechanoreceptors of arthropods. *Annu. Rev. Entomol*., 20: 381 – 397.

Medvedev LN, Pavlov SI, 1988. Mating behavior of the Chrysomelidae (Coleoptera). *Entomol. Rev*., 67: 100 – 109.

Merivee E, Märtmann H, Must A, Milius M, Williams I, Mänd M, 2008. Electrophysiological responses from neurons of antennal taste sensilla in the polyphagous predatory ground beetle *Pterostichus oblongopunctatus* (Fabricius, 1787) to plant sugars and amino acids. *J. Insect Physiol*., 54(8): 1213 – 1219.

Merivee E, Must A, Tooming E, Williams I, Sibul I, 2012. Sensitivity of antennal gustatory receptor neurones to aphid honeydew sugars in the carabid *Anchomenus dorsalis*. *Physiol. Entomol*., 37(4): 369 – 378.

Merivee E, Ploomi A, Luik A, Rahi M, Sammelselg V, 2001. Antennal sensilla of the ground beetle *Platynus dorsalis* (Pontoppidan, 1763) (Coleoptera, Carabidae). *Microsc. Res. Tech*., 55(5): 339 – 349.

Merivee E, Ploomi A, Rani M, Bresciani J, Ravn HP, Luik A, Sammelselg V, 2002. Antennal sensilla of the ground beetle *Bembidion properans* Steph. (Coleoptera: Carabidae). *Micron*, 33 (5): 429 – 440.

Merivee E, Rahi M, Luik A, 1999. Antennal sensilla of the click beetle *Melanotus villosus* (Geoffroy) (Coleoptera: Elateridae). *Int. J. Insect Morphol. Embryol*., 28(1 – 2): 41 – 51.

Milius M, Merivee E, Must A, Williams I, Tooming E, Luik A, 2011. Electrophysiological responses of the chemoreceptor neurones in the antennal taste sensilla to plant alkaloids and glucosides in a granivorous ground beetle. *Physiol. Entomol*., 36(4): 368 – 378.

Milius M, Merivee E, Williams I, Luik A, Mänd M, Must A, 2006. A new method for electrophysiological identification of antennal pH receptor cells in ground beetles: the example of *Pterostichus aethiops* (Panzer, 1796) (Coleoptera, Carabidae). *J. Insect Physiol*., 52 (9): 960 – 967.

Missbach C, Dweck HK, Vogel H, Vilcinskas A, Stensmyr MC, Hansson BS, Grosse-Wilde E, 2014. Evolution of insect olfactory receptors. *eLife*, 3: e02115.

Mu YL, Chen XS, 2014. Reproductive habit of *Epicauta impressicornis*. *Guizhou Agric. Sci*., 42(7): 49 – 52. [母银林, 陈祥盛, 2016. 扁角豆芫菁的繁殖习性观察. 贵州农业科学, 42(7): 49 – 52]

Mu YL, Chen XS, 2015. Studying the relationship between feeding and growing development of *Epicauta impressicornis* Pic larva. *J. Environ. Entomol*., 37(2): 407 – 411.

National Pharmacopoeia Editorial Board, 2010. The Pharmacopoeia of the People's Republic of China, Part One. China Medical Science and Technology Press, Beijing. 253. [中华人民共和国卫生部药典委员会, 2010. 中华人民共和国药典(一部). 北京: 中国医药科技出版社. 253]

Ochieng SA, Park KC, Zhu JW, Baker TC, 2000. Functional morphology of antennal chemoreceptors of the parasitoid *Microplitis croceipes* (Hymenoptera: Braconidae). *Arthropod Struct. Dev*., 29 (3): 231 – 240.

Pinto JD, 1991. The Taxonomy of North American *Epicauta* (Coleoptera: Meloidae), with a Revision of the Nominate Subgenus and a Survey of Courtship Behavior. UC Publications in Entomology (Book 110). University of California Press, California. 448 pp.

Pinto JD, 2009. Hypermetamorphosis. Academic Press, New York. 484 – 486.

Roh HS, Park KC, Oh HW, Park CG, 2016. Morphology and distribution of antennal sensilla of two tortricid moths, *Cydia pomonella* and *C. succedana* (Lepidoptera). *Microsc. Res. Tech*., 79(11): 1069 – 1081.

Ross KTA, Anderson M, 1987. Morphology of the antennal sensilla of the cabbage root fly, *Delia radicum* L. (Diptera: Anthomyiidae). *Int. J. Insect Morphol. Embryol*., 16(5 – 6): 331 – 342.

Ruchty M, Romani R, Kuebler LS, Ruschioni S, Roces F, Isidoro N, Kleineidam CJ, 2009. The thermo-sensitive sensilla coeloconica of leaf-cutting ants (*Atta vollenweideri*). *Arthropod Struct. Dev*., 38 (3): 195 – 205.

Saïd I, Tauban D, Renou M, Mori K, Rochat D, 2003. Structure and function of the antennal sensilla of the palm weevil *Rhynchophorus palmarum* (Coleoptera, Curculionidae). *J. Insect Physiol*., 49(9): 857 – 872.

Schneider D, 1964. Insect antenna. *Annu. Rev. Entomol*., 9: 103 – 122.

Sun F, Li XR, Liu XX, Zhang QW, 2010. Ultrastructure of six types of antennal sensilla in *Monochamus alternatus*. *Chin. Bull. Entomol*., 47(2): 347 – 354. [孙飞, 李祥瑞, 刘小侠, 张青文, 2016. 松褐天牛六种类型的触角感器的超微结构. 昆虫知识, 47(2): 347 – 354]

Tian XL, Yu HL, Su Q, Zhang JM, Li CR, Wang WK, Zhang GH, 2018. Sexual dimorphism of antenna of the scale insect *Drosicha corpulenta* (Kuwana) (Hemiptera: Coccoidae: Monophlebidae). *Zool. Anz*., 272: 65 – 72.

Tooming E, Merivee E, Must A, Luik A, Williams I, 2012. Antennal sugar sensitivity in the click beetle *Agriotes obscurus*. *Physiol. Entomol*., 37(4): 345 – 353.

Turco F, Di GA, Bologna MA, 2003. Sexual and cleaning behavior and related morphology in the genus *Cerocoma* (Coleoptera: Meloidae). *J. Insect Behav*., 16(2): 257 – 278.

Urbanek A, Łuszczek D, Kapusta M, 2016. Antennal and mouthpart sensilla of *Acanthoscelides obtectus* Say (Coleoptera: Bruchidae). *Microsc. Res. Tech*., 79(2): 1230 – 1235.

Xu LL, Zhang L, Yang YC, Ren LL, Wang T, Zong SX, 2015. Morphology of antennal, maxillary palp and labial palp sensilla in different larval instars of the Asian long-horned beetle, *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Cerambycidae). *Acta Zool*., 98(1): 20 – 31.

Zacharuk RY, 1985. Antennae and sensilla. In: Kerkut GA, Gilbert LI eds. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Pergamon Press, Oxford. 1 – 69.

Zauli A, Maurizi E, Carpaneto GM, Chiari S, Merivee E, Svensson GP, Giulio DA, 2016. Scanning electron microscopy analysis of the antennal sensilla in the rare saproxylic beetle *Elater ferrugineus* (Coleoptera: Elateridae). *Ital. J. Zool*., 83(3): 338 – 350.

Zhang GN, Wang JJ, 2010. Descriptions of antennal sensilla of the red-headed blister beetle, *Epicauta ruficeps* Illiger (Coleoptera, Meloidae). *Acta Zool. Sin*., 35(1): 1 – 10.

Zhang L, Feng YQ, Ren LL, Luo YQ, Zong SX, 2014. Antennal sensilla and ovipositor morphology of the European birch sawfly *Arge pullata* Zadd. (Hymenoptera: Tenthredinidae, Argidae). *Microsc. Res. Tech*., 77(6): 401 – 409.

扁角豆芫菁成虫雌雄异型触角感器精细结构观察

刘洋洋[1,2]，李国勇[3]，杨 琳[1,2]，陈祥盛[1,2,*]

（1. 贵州大学昆虫研究所，贵阳 550025；2. 贵州大学贵州省昆虫资源开发利用特色重点实验室，贵阳 550025；
3. 贵阳学院贵州省山地珍稀动物与经济昆虫重点实验室，贵阳 550005）

摘要：【目的】本研究旨在观察扁角豆芫菁 *Epicauta impressicornis* 主要触角感器的形态特征，为进一步开展扁角豆芫菁生物学和行为机制研究提供基础参考，也为今后的触角感受器电生理研究提供前提条件。【方法】对扁角豆芫菁 *E. impressicornis* 雌雄成虫触角感器进行了扫描电镜观察，并对雌雄成虫触角感器数量、分布及其差异进行了统计和比较分析。【结果】结果表明，其雌雄成虫触角感器存在性二型现象，二者的感器类型、数量及分布既有共性又存在明显差异。雌雄成虫触角共有的感器分为 7 种，即 2 种刺形感器（CH1 和 CH2），2 种锥形感器（SB1 和 SB2），1 种 Böhm 氏鬃毛（BB），1 种耳形感器（SA）和 1 种钟形感器（CA）；雄虫触角特有的感器类型包括 1 种刺形感器（CH3）和 1 种锥形感器（SB3），而雌性触角特有的感器类型包含 2 种锥形感器（SB4 和 SB5）和 1 种凹槽钉形感器（GP）。【结论】扁角豆芫菁成虫触角感受器类型丰富多样。根据触角感受器的形态、分布以及与之前报道结果的比较分析，推测其功能可能为信息素感器（CH1）、化学感器（CH2 和 GP）、嗅觉受体（CH3，SB1 – SB5，SA 和 CA）、机械感器（BB）和温度感器（GP 和 CA）。

关键词：扁角豆芫菁；性二型；触角感器；形态；分布；扫描电镜

中图分类号：Q964 **文献标识码：**A **文章编号：**0454-6296(2019)04-442-11

（责任编辑：赵利辉）